Journal of Food Innovation, Nutrition, and Environmental Sciences
Volume 2 (2025); Issue 3: 155-166
ISSN No:3078-5537

ORIGINAL ARTICLE

Nutritional Profiles, Functional Properties, and Sensory Characteristics of Crackers from Orange-fleshed and White-fleshed Sweet Potato Varieties

Chukwudi Ernest Ogbete *, & Miriam Ahunna Ofoeze

Biotechnology and Cassava Program, National Root Crops Research Institute, Km 8 Umuahia-Ikot Ekpene Road, P.M.B 7006, Umudike, Umuahia, Abia State, Nigeria.
DOI: https://doi.org/10.70851/jfines.2025.2(3).155.166

ABSTRACT

This study aimed to evaluate the nutritional composition, functional properties, and sensory attributes of crackers made from four sweet potato varieties (two orange-fleshed and two white-fleshed) alongside wheat, as a control. Healthy sweet potato tubers and wheat were processed into flour, which was used to produce crackers. The resulting flours were analyzed for their functional properties, whereas the crackers were analyzed for their proximate, mineral, vitamin, and sensory properties. Proximate analysis of crackers revealed moisture content ranging from 10.25 – 13.47 %, crude protein 2.28 – 10.27 %, crude fiber 0.54 – 2.00 %, crude fat 1.24 – 2.19 %, ash 2.66 – 6.87 %, and carbohydrate content 68.89 – 88.75 %. Functional properties of the flour samples showed bulk density values between 0.35 – 0.65 g/ml, swelling index from 1.64 – 1.85 ml/g, oil absorption capacity from 2.16 – 2.17 g/ml, and water absorption capacity between 2.10 – 2.14 g/ml. Mineral and vitamin analyses of the crackers indicated calcium levels ranging from 0.03 – 9.51 mg/100g, sodium 6.00 – 10.20 mg/100g, potassium 0.18 – 432 mg/100g, iron 0.32 – 4.25 mg/100g, phosphorus 0.30–115 mg/100g, vitamin A 7.02 – 1050 μg/100g, and vitamin C 1.15 – 45.23 mg/100g. Sensory evaluation results demonstrated that crackers made from wheat flour were the most preferred, followed by those made from the orange-fleshed sweet potato variety Umuspo 3. From this study, incorporating sweet potato flour; a locally cultivated tuber into cracker production, offers a cost-effective and sustainable solution to reduce wheat import dependency, thereby promoting food security and economic resilience.

Article history
Received;
05 June, 2025
Revised;
12 July, 2025
Accepted;
16 July, 2025

Keywords
Orange Fleshed Sweet Potato,
Nutritional composition,
Functional properties,
Sensory properties

*Corresponding author
E-mail: princeernestchukwudi16@gmail.com. (Chukwudi Ernest. O)
Peer review under responsibility of Journal of Food Innovations, Nutrition, and Environmental Sciences.

A Publication of EcoScribe Publishers company Limited, Uganda.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is a tuberous root of global significance, categorized among roots and tubers (Cartabiano-Leite *et al*., 2020). It is a crucial staple crop, especially in southern and eastern Africa, where it holds economic importance (Tumwegamire *et al*., 2007; Woolfe, 1992). According to FAOSTAT (2019), China leads in sweet potato production, followed by Nigeria, Tanzania, Indonesia, and Uganda, collectively producing an average of 112.8 million tons annually. In Africa, sweet potato is a staple crop, ranking as the third most essential food in eastern and central regions, the fourth in southern African nations, and the eighth in parts of western Africa (International Potato Center, 2017). Sweet potatoes are typically propagated vegetatively and are drought-resistant. Both their tuberous roots and leaves are consumed (Bovell-Benjamin, 2007). The crop exhibits a diversity of pulp colors, such as light yellow, orange, and purple, which correspond to different phytochemical contents. Orange-fleshed varieties are rich in carotenoids, particularly beta-carotene and provitamin A, while purple varieties are high in anthocyanins (Islam *et al.,* 2016; Chen *et al*., 2019; Zeist *et al*., 2022). As a result, selecting and biofortifying orange-fleshed sweet potato genotypes is a priority (Leal *et al*., 2021; Bento, 2021).

The orange-fleshed sweet potato (OFSP) is a distinct variety known for its vibrant color, sweet flavor, and exceptional nutritional value. OFSP is highly regarded for its vitamin A content, making it a critical crop for addressing vitamin A deficiency (VAD), a global public health issue that affects millions of pregnant women and preschool children (Low *et al*., 2017, Lubowa et al., 2014). In 2013, approximately one-third of preschool-aged children globally experienced VAD, with sub-Saharan Africa recording the highest incidence at 48 % (Uchendu and Oyediran, 2022). In Nigeria, a survey conducted between 2001 and 2003 revealed VAD prevalence rates of 29.5 % among preschoolers and 13 % among women of childbearing age (Adekambi *et al*., 2020). The high vitamin A content in OFSP highlights its potential to combat VAD and improve nutrition in regions where the deficiency is prevalent (Low *et al.,* 2017). Additionally, OFSP is rich in vitamin C, dietary fiber, minerals (manganese, copper, iron, and potassium), and antioxidants (Olagunju *et al*., 2021). It also enhances the flavor, sweetness, and color of food products, making it a versatile ingredient in processed foods across African countries such as South Africa, Kenya, Uganda, and Mozambique (Neela and Fanta, 2019). These foods are integral to improving household nutrition (Low *et al.,* 2017).

Sweet potato, often referred to as the "humble tuber," plays a pivotal role in global food systems and is recognized as a critical crop for strengthening food security and alleviating poverty (Mackay, 2009). It is the world's leading non-grain food commodity, with a production volume of 360 million tons (FAO, 2022). Potatoes are cultivated in 75% of countries worldwide, ranking as the third most essential crop for combating food insecurity (Devaux *et al*., 2021). Food security, defined as consistent access to sufficient, safe, and nutritious food, is vital in addressing the growing global demand for food (Wijesinha-Bettoni, 2019). The potato's significance stems from its high nutritional value, productivity, processing versatility, and wide-ranging culinary uses (National Potato Council of Kenya, 2018). In Nigeria, limited knowledge about the uses of sweet potatoes has restricted their potential applications. Snack production, such as biscuits, cakes, and chin-chin, primarily relies on wheat flour, despite the availability of root and tuber crops like cassava, sweet potato, and cocoyam, which can be processed into flour with high starch quality. Sweet potatoes, however, are mostly boiled or fried, with little exploration of alternative uses. Furthermore, insufficient research has been conducted to evaluate the nutrient composition, functional properties, and sensory qualities of biscuits made from orange-fleshed and white-fleshed sweet potato varieties. This study aims to address these gaps.

2. MATERIALS AND METHODS

2.1 Materials

The raw materials used in this study were four varieties of sweet potatoes: Umuspo 3 and Umuspo 4 herein named and represented as orange-fleshed sweet potato (OFSP), then white rose and round white herein named and represented as white-fleshed sweet potato (WFSP). Umuspo 3 and Umuspo 4 (OFSP) were harvested from the experimental farm of the National Root Crops Research Institute, Umudike, Abia State, Nigeria, at 5 months of maturity, while the white-fleshed (WFSP) varieties and wheat flour were purchased from *Ahiaukwu Olokoro* market, Umuahia, Abia State, Nigeria.

2.2 Preparation of raw materials

2.2.1 Sweet potato flour

5 kg of each sweet potato variety were cleaned and sorted, peeled with a kitchen knife, washed in portable water, chipped with a 300 – 100 kg/hr stainless steel potato chipping machine (Hytek Gme; Haryana, India), and oven-dried at 60 °C for 4 h with a hot air oven (Memmert Universal oven, Schwabach, Germany). The dried varieties of sweet potato were ground separately using a 300–1,300 kg/h grinding machine (Peruzzo C/17 R/17 hammer mills, Italy) into flour and subsequently sieved through a 20 mm metallic sieve to produce flour of fine texture. The resultant flour was packaged and stored at 4 °C in airtight polyethylene bags and kept for laboratory analysis. The flow diagram for the production of sweet potato flour is presented in **Figure 1**.

2.3 Production of crackers

The method described by Manley (2001), was used with modifications to produce the crackers. The sweet potato flours and wheat flour were each mixed with 2 ½ teaspoons of sugar and other desired dry ingredients like spices, herbs, and other ingredients as shown in **Table 1**. Butter was blended into the mixture until a uniform crumb texture formed. Water was then added gradually, followed by kneading to form a cohesive dough, and then chilled for 30 minutes. The dough was wrapped in foil and refrigerated for 30 minutes at 4 ^{0}C to allow the flavors to meld and the dough to rest, making it easier to roll out. The oven was preheated to 180 °C. The chilled dough was rolled out to about 1/4-inch thickness on a flat rolling board (sprinkled with flour). Desired shapes were cut out using metallic cookie cutters. Tiny holes were created in the dough with a fork to prevent puffing during baking and ensure even cooling, followed by transferring the crackers to a baking sheet lined with parchment paper, then baking for 12 minutes until a golden brown and slightly firm cracker was observed. The baked cracker was cooled at 25 °C for 15 min, and then packaged in an airtight metallic container for further laboratory analysis.

Fresh tubers of sweet potatoes
↓
Peeling
↓
Washing
↓
Chipping with machine
↓
Oven drying @ 60 ^{0}C for 4 h
↓
Grinding into flour
↓
Sieving
↓
Sweet potato flour
↓
Packaging and Storage

Fig.1. Flow diagram for the production of sweet potato flour

Table 1: Recipe for Production of Crackers

Ingredients	Quantity (by weight of total flour)
Sweet Potato /Wheat Flour	100 %
Butter	15 %
Water	60 %
Nutmeg	10 %
Egg	5 %
Baking powder	3 %
Vanilla flavor	5 %
Sugar	50 %

Sweet Potato Flours
↓
Mixing of dry ingredients (sugar, spices and herbs)
↓
Addition of butter (Blend until crumbly texture forms)
↓
Addition of water (Knead until a cohesive dough is formed)
↓
Refrigeration of dough (Chill @ 4 ^{0}C for 30 min)
↓
Roll Dough (To 1/4-Inch Thickness)
↓
Cut into Desired Shapes (Use metallic cookie cutters)
↓
Pierce Dough with Fork (to prevent puffing during baking)
↓
Bake (at 180 °C for 12 min)
↓
Cool (at 25 °C 15 min)
↓
Package
↓
Crackers

Fig.2. Flow diagram for the production of sweet potato crackers

2.4 Determination of mineral content of crackers

Calcium, magnesium, and potassium contents of the cracker samples were determined with the complexometric titration method of Onwuka (2018). Sodium and Iron contents were determined according to the spectrophotometric method of AOAC (2010).

2.5 Determination of Vitamin content of crackers

Vitamin A (carotenoid) and Vitamin C contents (Ascorbic acid) of the cracker samples were determined using the method described by Aremu and Nweze (2017).

2.6 Determination of proximate composition of crackers

The moisture, crude protein, fat, crude fiber, and ash contents of the cracker samples were determined in duplicate using established analytical procedures described by Onwuka (2018). The carbohydrate content was estimated by a difference of 100% after accounting for moisture**.**

2.7 Analysis of functional properties of the sweet potato flour

The functional properties (water absorption capacity, oil absorption capacity, swelling index, and bulk density) of the sweet potato flours used in the production of the crackers were determined according to the methods described by Onwuka (2018).

2.8 Sensory evaluation

Sensory attributes of the cracker samples were evaluated using the method described by Iwe (2014). A total of 25 panelists, randomly selected from the laboratory staff and students of the Department of Food Science and Technology at Michael Okpara University of Agriculture, Umudike, Abia State, participated in the evaluation. The panelists assessed the samples based on appearance, taste, texture, aroma, and overall acceptability. Before the evaluation, the panelists received instructions on how to assess the sensory properties of the samples. The samples were packaged identically and labeled with appropriate codes to ensure unbiased evaluation. Panelists were provided with potable water to rinse their mouths after tasting each sample to prevent any carryover effects on the taste of subsequent samples.

The quality attributes (appearance, taste, texture, aroma, and general acceptability) were rated using a 9-point Hedonic scale. The scale ranged from "like extremely" (9) to "dislike extremely" (1). Scores from "like extremely" to "like slightly" represented positive (good) attributes, while scores from "dislike slightly" to "dislike extremely" indicated negative (poor) attributes. A score of "neither like nor dislike" (5) indicated a neutral perception, meaning the product was neither good nor bad.

2.9 Statistical Analysis

Data were analyzed using one-way analysis of variance (ANOVA) based on a completely randomized design with SPSS version 22.0. Differences among treatment means were determined using Duncan's Multiple Range Test at a 95 % confidence level ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1 Mineral and vitamin composition of the crackers

Table 2 presents the mineral and vitamin composition of the cracker samples, which reveals the significant differences among them. These variations reflect the influence of different sweet potato varieties and wheat flour on the nutritional quality of the products. These findings are crucial for the development of functional foods designed to address micronutrient deficiencies and promote dietary diversity, particularly in regions affected by hidden hunger and malnutrition (Low *et al*., 2017).

Table 2: Mineral and Vitamin composition of the cracker samples

Samples	Calcium (mg/100g)	Sodium (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Phosphorus (mg/100g)	Vitamin A (µg/100g)	Vitamin C (mg/100g)
A	0.03^{d}	10.20^{a}	432.00^{a}	0.32^{c}	115.00^{a}	1050.00^{a}	45.23^{a}
B	0.05^{d}	9.80^{ab}	410.00^{a}	0.35^{c}	109.00^{a}	998.50^{a}	42.12^{a}
C	9.51^{a}	6.50^{c}	230.00^{b}	3.21^{b}	45.00^{b}	75.00^{c}	12.30^{c}
D	8.90^{b}	6.00^{c}	198.00^{b}	3.45^{b}	48.00^{b}	81.20^{c}	11.80^{c}
E	7.20^{c}	7.80^{bc}	0.18^{c}	4.25^{a}	0.30^{c}	7.02^{d}	1.15^{d}
LSD	0.35	0.85	20.55	0.4	5.1	25.4	1.8

Values are means of duplicate determinations. Means with different superscripts along a column are significantly different at ($p < 0.05$). Key: A = Umuspo3, B = Umuspo 4, C = White rose, D = Round white, E = Wheat

Calcium

The White-fleshed sweet potato crackers (Samples C and D) exhibited the highest calcium content (9.51 and 8.90 mg/100 g, respectively), surpassing both OFSP and wheat-based samples. This agrees with Bello and Olumiyiwa (2008), who reported higher mineral levels in root-based food products. The relatively low calcium concentrations in OFSP samples (A and B) and the wheat-based sample (E) may be due to varietal traits or mineral retention capacity during processing (Olagunju *et al*., 2021). Calcium is vital for skeletal integrity, muscle contraction, and blood clotting (Bovell-Benjamin, 2007). These findings align with Aina *et al*. (2012), who observed that cassava-enriched crackers had higher calcium content compared to those made from wheat flour alone.

Sodium

All samples contained relatively low sodium concentrations, with Umuspo 3 (Sample A) and Umuspo 4 (Sample B) showing the highest values (10.20 and 9.80 mg/100 g, respectively). These differences may stem from the natural mineral content of sweet potato varieties or salt additions during formulation. Wheat (Sample E) recorded 7.80 mg/100 g, while white-fleshed varieties (Samples C and D) had the lowest sodium levels (6.50 and 6.00 mg/100 g). Similar sodium trends were reported in sweet potato–wheat composite cookies (Adelakun *et al*., 2013). Although sodium supports nerve and fluid balance, excessive intake is associated with hypertension, hence moderate levels as seen here may be beneficial (He and MacGregor, 2009; Onwuka, 2018).

Potassium

OFSP crackers (Samples A and B) were rich in potassium, with values of 432.00 and 410.00 mg/100 g, respectively. This aligns with previous reports highlighting OFSP as a potassium-dense root crop (Olagunju *et al*., 2021). Samples C and D recorded moderate levels (230.00 and 198.00 mg/100 g), while Sample E (wheat-based) showed a negligible amount (0.18 mg/100 g). Potassium plays a role in cellular fluid balance and neuromuscular function. Its high content in OFSP crackers may help mitigate hypertension risk (D'Elia *et al*., 2011; Neela and Fanta, 2019). Similar findings were reported by Olatunde *et al.* (2016) in OFSP-enriched cookies. Potassium is essential for fluid balance, nerve impulse transmission, and muscle function. A high potassium intake has been linked with reduced blood pressure and a lower risk of cardiovascular diseases (Neela and Fanta, 2019).

Iron

Iron content ranged significantly, with Sample E (wheat-based) containing the highest level (4.25 mg/100 g), likely due to intrinsic grain properties (Hurrell, 2002). Samples C and D (WFSP) showed moderate levels (3.21 and 3.45 mg/100 g), while OFSP samples A and B had the lowest values (0.32 and 0.35 mg/100 g). These results align with Fadairo *et al*. (2018), who reported higher iron in wheat-based products compared to tuber flours. The unexpectedly low iron in OFSP may result from varietal differences or processing losses (Uchendu and Oyediran, 2022). Iron is essential for oxygen transport and cognitive function, and its adequate intake is especially critical for women and children.

Phosphorus

Phosphorus content varied across the samples, with OFSP-based crackers (Samples A and B) having the highest levels (115.00 and 109.00 mg/100 g), likely due to inherent mineral richness. These values are consistent with studies reporting phosphorus content of 43 – 310 mg/100 g in OFSP-based baked goods (ASRJETS, 2021). White-fleshed varieties (C and D) had moderate levels (45.00 and 48.00 mg/100 g), while wheat-based Sample E had negligible phosphorus (0.30 mg/100 g). Phosphorus supports bone health and energy metabolism but must be moderated in individuals with kidney disease (Butt and Batool, 2010; Calvo and Uribarri, 2013).

Vitamin A

OFSP crackers (Samples A and B) exhibited remarkably high vitamin A contents (1050.00 and 998.50 µg/100 g), attributed to their rich provitamin A carotenoid profile. These levels are consistent with reports showing OFSP products containing up to 19.86 mg/100 g β-carotene and over 1400 µg/100 g RAE (Wafula *et al*., 2021). In contrast, white-fleshed samples (C and D) had lower values (75.00 and 81.20 µg/100 g), and Sample E (wheat) had minimal vitamin A (7.02 µg/100 g). These findings reinforce OFSP's role in combating vitamin A deficiency in sub-Saharan Africa (Low *et al*., 2017; Khanam *et al*., 2021), and Oti *et al*. (2020), who found enhanced vitamin A levels in snacks enriched with OFSP, reinforcing the nutritional advantage of biofortified root crops. Vitamin A is essential for vision, immunity, and skin health (Tang, 2010).

Vitamin C

Vitamin C content was highest in OFSP crackers, Sample A (45.23 mg/100 g) and Sample B (42.12 mg/100 g), followed by WFSP samples C (12.30 mg/100 g) and D (11.80 mg/100 g). Sample E had the lowest (1.15 mg/100 g). This agrees with the values reported in OFSP-based baked goods, ranging from 0.913 to 1.742 mg/100 g post-baking (Alam *et al*., 2021). Vitamin C enhances immune defense, iron absorption, and collagen synthesis (Padayatty *et al*., 2003; Olagunju *et al*., 2021). OFSP's retention of vitamin C during processing highlights its suitability for functional foods aimed at boosting immunity.

3.2 Proximate composition of the Cracker samples.

Figure 3 illustrates the proximate composition of five samples: Umuspo 3 and 4 orange-fleshed sweet potato (A and B respectively), White rose and round white, white-fleshed sweet potato (C and D respectively), and wheat (E, the control) across six parameters: moisture (%), Crude Protein (%), Crude Fiber (%), Crude Fat (%), Ash (%), and Carbohydrates (CHO, %).

3.2.1 Moisture

Samples A (Umuspo 3), B (Umuspo 4), C (White rose), and D (Round white) which had moisture contents (12.87 %, 12.91 %, 13. 13 % and 13.47 % respectively) were statistically similar and below the 14 % maximum recommended for crackers to ensure stability, but above the 5 % ideal for longer shelf life (Rebellato *et al*., 2015). Sample E (wheat) was significantly drier (10.25 %). Comparable studies by Ujong *et al*. (2023) reported moisture values of 9.2 –11.5 % in composite crackers, which suggests that moisture in Samples A, B, C and D may slightly reduce shelf life relative to drier formulations.

3.2.2 Crude protein

Samples A (Umuspo 3), B (Umuspo 4), C (White rose), and D (Round white) have very low and similar crude protein levels (2.28 %, 2.30 %, 2.32 % and 2.36 % respectively), and were consistent with the 2.0 – 3.8 % protein reported in root-tuber based crackers by Ujong *et al*. (2023). Sample E (Wheat) recorded a higher value (10.27 %), which aligns with the 9.6 – 11.2 % protein range in wheat-based crackers enriched with legumes and whole grains (Karim *et al*., 2021), confirming wheat's superior protein contribution.

3.2.3 Crude fiber

Samples A (Umuspo 3), B (Umuspo 4), C (White rose), and D (Round white) showed minimal fiber content (0.54 %, 0.57 %, 0.63 % and 0.67 % respectively), and are lower than the 1.1 – 2.8 % range observed in enriched crackers by Adeyeye *et al*. (2023). Sample E (2.00 %) falls within this range, suggesting the incorporation of wheat enhanced dietary fiber significantly.

3.1.4 Crude fat

Crude fat values are low across samples, with Samples A (Umuspo 3), B (Umuspo 4), C (White rose), and D (Round white) having values of 1.24 %, 1.29 %, 1.34 % and 1.48 % respectively. These values are within the typical 1.0 – 2.5 % range observed in tuber-based crackers (Aiyesanmi and Oguntokun, 1996). Sample E had a slightly higher fat content (2.19 %), consistent with wheat-based crackers reported by Bello and Olumiyiwa (2008), which had values between 2.1– 3.4 %. Food with high fat content contributes significantly to the energy requirements of humans. Flours with high-fat content are also good as flavor enhancers and useful in improving the palatability of food in which it is incorporated (Aiyesanmi and Oguntokun, 1996).

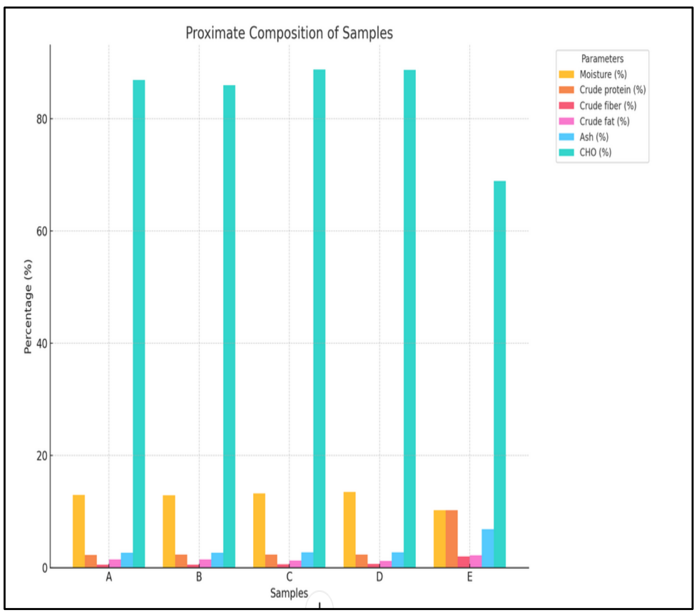

Fig.3. Proximate composition of the crackers

3.2.5 Ash

Samples A (Umuspo 3), B (Umuspo 4), C (White rose), and D (Round white) have similar ash content with the values: 2.66 %, 2.69 %, 2, 74 % and 2.76 % respectively, which represents the mineral composition. These values are in line with the 2.5 – 3.0 % values seen in sweet potato-enriched crackers (Adeyeye *et al*., 2023). However, Sample E's significantly higher ash content (6.87 %) surpasses the 3.5 – 5.5 % range noted in mineral-fortified wheat crackers (Bello and Olumiyiwa, 2008), suggesting elevated mineral presence. Food materials with a high percentage of ash content are likely to have high concentrations of mineral elements, which are expected to speed up metabolic processes and improve human growth and development (Bello and Olumiyiwa, 2008).

3.2.6 Carbohydrates

Samples A (Umuspo 3), B (Umuspo 4), C (White rose), and D (Round white) have high carbohydrate levels (86.00 %, 86.82 %, 87.23 % and 88.75 % respectively), indicating these samples are rich in energy-providing carbohydrates. These values align with the 85 – 89 % range documented in tuber-dominant cracker formulations (Butt and Batool, 2010). Sample E had lower carbohydrate (68.89 %), which is consistent with values of 65 – 70 % for wheat-legume blended crackers, due to higher protein, fiber, and ash contents. Carbohydrates are good sources of energy (Butt and Batool, 2010). The good carbohydrate content of these crackers would make them a good source of energy in breakfast formulations.

3.3 Functional properties of the flour samples

Table 3 presents the functional properties of the flour samples.

3.3.1 Bulk density

Bulk density reflects the compactness of the sample particles and is crucial for packaging and transportation efficiency in food systems (Chandra and Samsher, 2013). Wheat flour (0.73 g/ml) exhibited the highest BD, significantly different ($p < 0.05$) from other samples, indicating it was the most compact among the tested varieties. White rose and Round white flours (0.35 and 0.32 g/ml, respectively) had the lowest BD, which might be attributed to their particle size or porosity, making them more suitable for applications requiring lower densities (e.g., baked goods). The variation in BD suggests that different processing techniques or varietal characteristics could influence particle structure (Onwuka, 2018).

3.3.2 Swelling index

The Swelling index (SI) indicates the ability of the sample to absorb water and expand, a property essential for food products like thickening agents or pastes (Ikegwu *et al*., 2010). Wheat flour (1.89 ml/g) showed the highest SI, significantly greater ($p < 0.05$) than other samples, suggesting a superior capacity to expand and absorb water. White rose and Round white flours (1.50 and 1.48 ml/g, respectively) had the lowest SI, potentially limiting their use in applications requiring high water absorption or swelling. A higher swelling index correlates with a high amylopectin content or low lipid content in starchy foods (Ikegwu *et al*., 2010).

Table 3. Functional properties of the flour samples

Samples	BD (g/ml)	SI (ml/G)	OAC (ml/g)	WAC (g/ml)
A	$0.58^b \pm 0.42$	$1.66^b \pm 0.41$	$2.16^a \pm 0.42$	$2.26^a \pm 0.44$
B	$0.59^b \pm 0.44$	$1.64^b \pm 0.37$	$2.15^a \pm 0.42$	$2.25^a \pm 0.37$
C	$0.35^c \pm 0.37$	$1.50^c \pm 0.59$	$2.15^a \pm 0.42$	$2.26^a \pm 0.37$
D	$0.32^c \pm 0.40$	$1.48^c \pm 0.60$	$2.14^a \pm 0.37$	$2.23^a \pm 0.37$
E	$0.73^a \pm 0.40$	$1.89^a \pm 0.40$	$2.17^a \pm 0.37$	$2.15^a \pm 0.60$
LSD	0.22	0.32	0.18	0.46

Note: values are means of duplicate determinations. Means with different superscripts along a column are significantly different at ($p < 0.05$). **Key**: A = Umuspo3, B = Umuspo 4, C = White rose, D = Round white, E = Wheat, BD = Bulk density, SI = Swelling Index, OAC = Oil absorption capacity, WAC = Water absorption capacity,

3.3.3 Oil Absorption Capacity (OAC)

OAC measures the ability of a sample to bind oil, which enhances flavor retention and mouthfeel in food systems such as sausages or emulsions (Kaur and Singh, 2006). All the samples showed similar OAC values (2.14 – 2.17 ml/g) with no significant differences, indicating that their oil-binding capacities are comparable. The consistent OAC across all samples suggests similar protein and lipid profiles, which align with findings by Adebowale *et al*. (2005) on starchy crops.

3.3.4 Water Absorption Capacity (WAC)

WAC is an indicator of the sample's ability to retain water, important in dough preparation and food formulations requiring hydration (Oti and Akobundu, 2007). Umuspo 3 flour (2.26 g/ml) had the highest WAC, closely followed by samples Umuspo 4 flour, White rose flour, and round white, while Wheat flour (2.15 g/ml) recorded the lowest value. The high WAC of Umuspo 3 and 4 flours might indicate a higher hydrophilic nature, likely due to a higher starch content or finer particle size (Osundahunsi *et al*., 2013). The minimal variation in WAC suggests that the samples are suitable for similar applications, such as baked goods or soups, requiring water retention.

3.5 Sensory properties of the crackers

The heatmap below (**Figure 4**) represents the sensory evaluation scores for the cracker samples. In the map, the darker blue shades represent higher sensory scores, indicating better performance. Lighter shades signify lower scores, reflecting areas where the samples underperformed. Sample E (Wheat cracker) dominated the heatmap with the highest scores in all attributes, especially Taste (6.87) and Flavour (6.33). It stood out as the most preferred sample overall, reflected by darker shades in all its rows. Sample A (Umuspo 3) scored well in Colour (5.96) and General acceptability (GA) (5.26) but had moderate scores in other attributes. Sample B (Umuspo 4) showed consistency, with relatively balanced scores, but none was exceptionally high. Sample C (White rose) showed the weakest performer, particularly in Flavor (3.96) and GA (4.23), as indicated by the lighter shades. Sample D (Round white) was similar to Sample C (White rose) in all the parameters evaluated on but slightly better in GA (4.26) and Color (4.73).

The sensory attributes of the crackers showed significant differences ($p \leq 0.05$), which were observed across all evaluated parameters, texture, taste, flavour, colour, and general acceptability (GA).

The heat-based cracker (Sample E) recorded the highest scores across all sensory attributes, with values ranging from 5.40 (texture) to 6.87 (taste), indicating strong consumer preference. These results align with previous studies indicating that wheat flour typically yields products with familiar and desirable sensory qualities (Olapade and Ogunade, 2014). However, this sample served as a benchmark for evaluating the performance of sweet potato-based alternatives. Among the sweet potato varieties, Umuspo 3 (Sample A) showed the most promising sensory profile, with GA (5.26), colour (5.96), and flavour (4.97) scores which is closest to the wheat control. This supports reports that orange-fleshed varieties like Umuspo 3 are superior in visual appeal and taste, largely due to their natural sweetness and higher β-carotene content (Low *et al*., 2007; Laurie *et al*., 2013). Umuspo 3's high performance makes it a viable substitute for wheat in functional snack products, especially in vitamin A intervention programs. Umuspo 4 (Sample B) followed closely in terms of colour (5.98) and taste (4.94), though its flavour (4.68) and GA (5.00) were slightly lower. The sensory appeal of Umuspo 4 may still be attributed to its orange-fleshed nature, which enhances sweetness and colour. Nonetheless, Umuspo 3 outperformed it across nearly all parameters, a trend consistent with findings by Owori and Ssemakula (2012), who identified intra-varietal differences in sweetness, starch content, and consumer preference.

Crackers from White Rose (Sample C) and Round White (Sample D), both white-fleshed varieties, showed lower sensory scores in flavour (3.96 and 3.98, respectively) and GA (4.23 and 4.26), suggesting a general consumer disinterest. These results may stem from their lack of pigmentation and lower sugar content, which impact both taste and appearance (Adegunwa *et al*., 2014). Although their texture and colour remained within acceptable ranges, their overall lower ranking implies limited potential as stand-alone substitutes in cracker formulation. The colour scores of sweet potato-based crackers were most notable for Umuspo 3 and Umuspo 4 (5.96 and 5.98), showing parity with the wheat control (6.30). This reflects consumer preference for vibrant colours, particularly the golden-orange hue derived from OFSP, which is perceived as nutritious and appetizing (Laurie *et al*., 2013; van Jaarsveld *et al*., 2006). While texture scores were relatively uniform across the sweet potato samples (4.20 – 4.35), Umuspo 3 again performed best among them. This suggests that OFSP varieties may influence desirable crispness when appropriately processed, as noted by Bovell-Benjamin (2007).

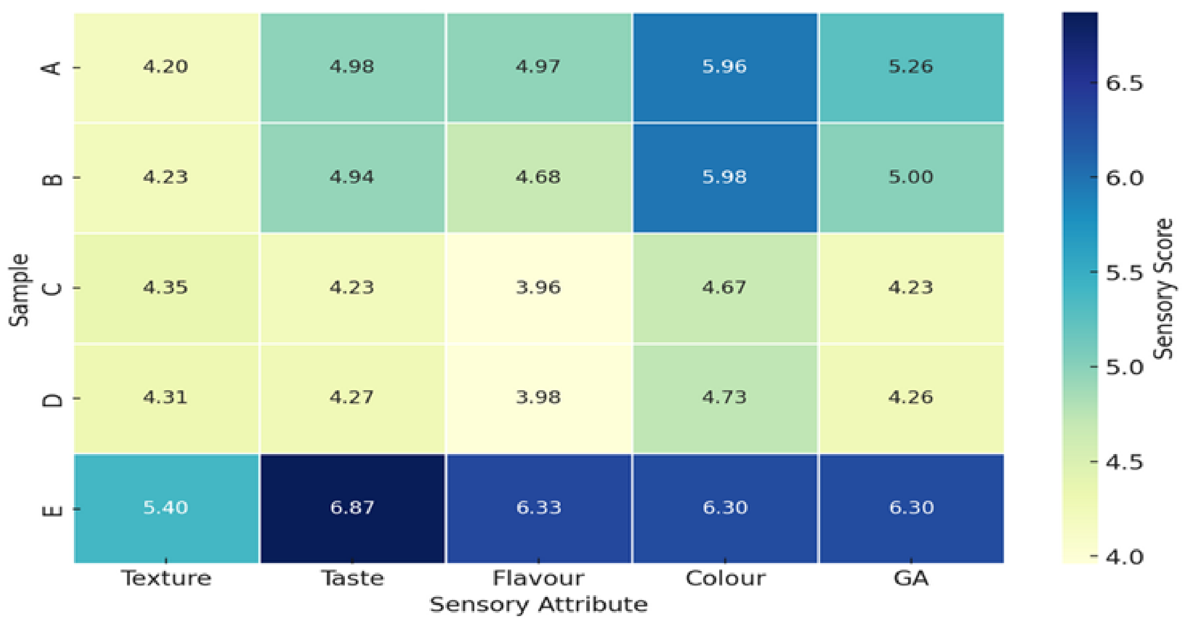

Fig. 4. Heatmap of the sensory evaluation scores for the cracker samples

CONCLUSION

This study evaluated the nutritional composition, functional properties, and sensory qualities of crackers produced from four sweet potato varieties, two orange-fleshed (Umuspo 3 and Umuspo 4) and two white-fleshed (White Rose and Round White) compared with a wheat-based control. The findings demonstrated that sweet potato-based crackers, particularly those made with orange-fleshed varieties, are rich in provitamin A (β-carotene), vitamin C, potassium, and carbohydrates, contributing significantly to their nutritional value. Functional properties such as water and oil absorption capacities, bulk density, and swelling index revealed that sweet potato flours exhibit qualities conducive for cracker production. Sensory evaluation indicated that although the wheat-based crackers were most preferred overall, crackers made with Umuspo 3 flour showed promising acceptability, especially in color, flavor, and general appeal. The orange pigmentation, nutritional superiority, and moderate sensory acceptability of OFSP-based crackers support their potential as viable alternatives to wheat in snack food production. Overall, integrating sweet potato, particularly orange-fleshed varieties, into cracker formulation presents a sustainable and nutritious strategy to reduce wheat import dependence, combat vitamin A deficiency, and promote food security in Nigeria and similar regions.

ETHICAL APPROVAL STATEMENT

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013), which emphasize respect for persons, informed consent, and the prioritization of participant welfare. Ethical approval was obtained from the Institutional Research Ethics Committee of the National Root Crops Research Institute (NRCRI), Umudike, Nigeria, and all participants provided informed consent prior to their involvement in the study.

ACKNOWLEDGMENTS

The authors sincerely thank the Biochemistry Laboratory of NRCRI, Umudike, for providing research facilities and support. Appreciation also goes to the lab staff and Food Science students of Michael Okpara University of Agriculture Umudike, for assisting with the sensory evaluation.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest in this work.

DATA AVAILABILITY

The data used to support the findings of this study are available upon request from the corresponding author.

REFERENCES

Adebowale, K. O., Sanni, S. A., and Oladapo, F. O. (2005). Chemical and functional properties of cassava starch derivatives. *International Journal of Food Properties*, 8(2), 305–315.

Adegunwa, M. O., Alamu, E. O., Bakare, H. A., & Godwin, O. (2014). Physicochemical and functional properties of sweet potato flour. *International Journal of Food Science and Nutrition Engineering*, 4(5), 83–87.

Adekambi S. A., Okello J. J., Abidin P. E., and Carey E. (2020). Effect of exposure to bio-fortified crops on smallholder farm household adoption decisions: the case of orange-fleshed sweet potato in Ghana and Nigeria, *Scientific African. 8 articles* e00362.

Adelakun, O. E., Oyelade, O. J., Ade-Omowaye, B. I. O., and Adeyemi, I. A. (2013). Chemical composition and sensory properties of sweet potato–wheat composite cookies. *African Journal of Food, Agriculture, Nutrition and Development*, 13(2). https://doi.org/10.18697/ajfand.58.11073

Adeyeye, S. A. O., Adebayo, O. A., and Alagbe, F. O. (2023). Evaluation of fiber and mineral content in composite crackers. *African Journal of Food Research and Nutrition*, 3(4), 77–88.

Aina, A. J., Falade, K. O., Akingbala, J. O., and Titus, P. (2012). Quality evaluation of cassava–wheat composite crackers. *Nigerian Food Journal*, 30(1), 105–112. https://doi.org/10.1016/S0189-7241(15)30074-0

Aiyesanmi, A.F., and Oguntokun, M.O. (1996). Nutrient composition of *Dioclea reflexa* seed: An underutilized edible legume. *Rivista Italiana Delle Sostanze Grasse*, 73, 521-523.

Alam, M., Ghosh, S., and Low, J. W. (2021). Beta carotene, vitamin C, zinc and iron content of bread, biscuit and cake made with OFSP puree. International Potato Center (CIP). https://hdl.handle.net/10568/114214

Aremu, S.O. and Nweze, C.C. (2017). Determination of Vitamin A Content from Selected Nigerian Fruits Using Spectrophotometric Method. *Bangladesh Journal of Scientific and Industrial Research*, 52, 153-158.

ASRJETS. (2021). Effect of incorporating OFSP flour, starch, and non-starch residue flour to wheat on the quality of cookies. *American Scientific Research Journal for Engineering, Technology, and Sciences*, 77(1), 200–220.

Bello, F. A., & Olumiyiwa, S. (2008). Ash content and mineral quality of composite flour crackers. *Nigerian Food Journal*, 26(1), 24–31.

Bello, M. and Olumuyiwa, S.F., (2018). Studies on the chemical compositions and anti-nutrients of some lesser-known Nigerian fruits. *African Journal of Biotechnology* Vol. 7 (21), pp. 3972-3979

Bento, K. J. (2021). Use of orange-fleshed sweet potato [Ipomoea batatas (L) Lam] to combat vitamin A deficiency. *International Journal of Plant Breeding and Crop Science*, 8: 1033-1038.

Bovell-Benjamin, A. C. (2007). Sweet potato: a review of its past, present, and future role in human nutrition, *Advanced Food Nutrition Resources* 52: 1-59

Butt, S.M. and Batool, R. (2010). Nutritional and Functional Properties of Some Promising Legume Protein Isolates. *Pakistan Journal of Nutrition*, 9, 373-379

Calvo, M. S., and Uribarri, J. (2013). Public health impact of dietary phosphorus excess. *Advances in Nutrition,* 4(3), 312–321.

Cartabiano-leite, C. E., Porcu, O. M., and Casas, A. F. (2020). Sweet Potato (*Ipomoea batatas* L. Lam) Nutritional Potential and Social Relevance: A Review. *History*, 11: 23-40.

Chandra, S., and Samsher. (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research*, 8(38), 4849–4852.

Chen, C.C., Lin, C., Chen, M.H., and Chiang, P.Y. (2019). Stability and Quality of Anthocyanin in Purple Sweet Potato Extracts. *Foods*. 8(9):393. https://doi.org/10.3390/foods8090393. PMID: 31489943; PMCID: PMC6770014.

D'Elia, L., Barba, G., Cappuccio, F. P., and Strazzullo, P. (2011). Potassium intake, stroke, and cardiovascular disease: A meta-analysis of prospective studies. *Journal of the American College of Cardiology*, 57(10), 1210–1219. https://doi.org/10.1016/j.jacc.2010.09.070

Devaux, A., Kromann, P., and Ortiz, O. (2014). Potatoes for Sustainable Global Food Security. *Potato Research*, 57(3–4), 185–199. https://doi.org/10.1007/s11540-014-9265-1

Fadairo, O. S., Akinoso, R., and Adebowale, A. A. (2018). Nutritional evaluation of cookies produced from wheat and tuber flours. *Nigerian Journal of Agriculture and Food Environment,* 14(3), 79–85. https://doi.org/10.51406/njafe.v14i3.2075

Food and Agriculture Organization (FAO). (2022). FAOSTAT. https://www.fao.org/faostat/en/#data/QCL

Food and Agriculture Organization (FAO). (2019). FAOSTAT. http://www.fao.org/faostat/en/#data/QC

He, F. J., and MacGregor, G. A. (2009). Reducing population salt intake. World Health Organization Bulletin, 87, 763–769. https://npck.org/national-potato-strategy-2021-2025/

Hurrell, R. F. (2002). Fortification: Overcoming technical and practical barriers. *The Journal of Nutrition*, 132(4), 806S–812S.

Ikegwu, O. J., Okechukwu, P. E., and Ekumankama, E. O. (2010). Physico-chemical and pasting characteristics of flour and starch from Achi (*Brachystegia eurycoma*) seed. *Journal of Food Technology*, 8(2), 58–66.

International Potato Center (2017). Sweet potato in Africa. Retrieved from https://cipotato.org/research/sweetpotato-in-africa on November 1, 2024

Islam, S.N., Tania N., Parveen, B. and Monira, A. (2016). Carotenoids and β-carotene in orange-fleshed sweet potato: A possible solution to vitamin A deficiency. *Food Chemistry*, 199: 628-631

Karim, A. A., Aziz, N. A. A., Fazilah, A., and Zaidul, I. S. M. (2021). Nutritional improvement of crackers using legume and tuber blends. *Food Production, Processing and Nutrition*, 3(2), 12–21. https://doi.org/10.1186/s43014-021-00048-7

Khanam, J., Mahdi, S. F. A., Ahsan, M., and Islam, S. N. (2021). Orange-fleshed sweet potato: A nutrition-sensitive functional food for a possible dietary approach to vitamin A deficiency and undernutrition. *World Journal of Advanced Research and Reviews*, 12(3), 645–651. https://doi.org/10.30574/wjarr.2021.12.3.0520

Khanam, F., Rahman, M. M., & Begum, S. (2021). Role of biofortified orange-fleshed sweet potato in vitamin A deficiency reduction. *Research Society for Development Journal*, 10(7), 1225–1234.

Laurie, S. M., Faber, M., Claasen, N., and van Jaarsveld, P. J. (2013). The use of orange-fleshed sweet potato to address vitamin A deficiency in South Africa. *Food Research International,* 52(1), 1–9.

Leal, M. H. S. (2021). Selection of new sweet potato genotypes based on production parameters, physical root characteristics and resistance to Euscepes postfasciatus *Journal of Crop Science and Biotechnology*, 24: 349-360.

Low J. W., Mwanga R. O., Andrade M., Carey E., and Ball A. M. (2017). Tackling vitamin, A deficiency with biofortified sweetpotato in sub-Saharan Africa, *Global Food Security*, 14, 23–30, https://doi.org/10.1016/j.gfs.2017.01.004, 2-s2.0-85015287933, 28989861

Low, J. W., Arimond, M., Osman, N., Cunguara, B., Zano, F., & Tschirley, D. (2007). A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *The Journal of Nutrition*, 137(5), 1320–1327.

Low, J. W., Mwanga, R. O. M., Andrade, M., Carey, E., Ball, A. M., and Elma, B. (2017). Bio-fortified crops to improve micronutrient status: A global perspective. *Global Food Security*, 12, 49–58. https://doi.org/10.1016/j.gfs.2017.01.003

Lubowa, M., Yerbie, A., Kisambira, A. (2014). Development of Orange Fleshed Sweet Potato (OFSP) Based Juice Drink to Help Reduce on Vitamin A Deficiency.

International Journal of Science and Research (IJSR) 3(7): 283-289

Mackay, G. R. (2009). New light on a hidden treasure. *Experimental Agriculture*, 45(3), 375–393. https://doi.org/10.1017/S0014479709990344

Manley, D. (2001). Biscuit, cracker and cookies recipes for the food industry (pp. 28–34). Woodhead Publishing.

National Potato Council of Kenya. (2016). The National Potato Strategy 2016–2020. Nairobi, Kenya: Ministry of Agriculture, Livestock and Fisheries. https://npck.org/wp-content/uploads/2020/04/National-Potato-Strategy-2016-2020.pdf

Neela, S., and Fanta, S. W. (2019). Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin a deficiency, Food Science & Nutrition. 7, no. 6, 1920–1945, https://doi.org/10.1002/fsn3.1063, 2-s2.0-85067866861, 31289641. *Nutrition and Healthy Diets*. Fao 2009

Olagunju A. I., Omoba O. S., Awolu O. O., Rotowa K. O., Oloniyo R. O., and Ogunowo O. C., (2021). Physiochemical, antioxidant properties and carotenoid retention/loss of culinary processed orange-fleshed sweet potato, *Journal of Culinary Science & Technology*. 19, no. 6, 535–554, https://doi.org/10.1080/15428052.2020.1799278.

Olagunju, F. I., Adebayo, S. E., and Ajeigbe, K. O. (2021). Nutritional potential of orange-fleshed sweet potato. *International Journal of Food Studies*, 10(2), 122–134. https://doi.org/10.7455/ijfs.2021.1133

Olapade, A. A., and Ogunade, I. M. (2014). Production and evaluation of flours and crunchy snacks from sweet potato and maize flour blends. International *Journal of Food Science and Nutrition Engineering*, 4(6), 149–154.

Olatunde, O. O., Henshaw, F. O., and Idowu, M. A. (2016). Evaluation of cookies enriched with orange-fleshed sweet potato (OFSP) flour. *International Food Research Journal*, 23(1), 240–247.

Onwuka G.I. (2018). Food Analysis and Instrumentation-Theory and Practice. Second Edition. Lagos Nigeria. *Naphtali Prints*, 365–390.

Osundahunsi, O. F., Fagbemi, T. N., Kesselman, E., and Shimoni, E. (2013). Comparison of the physicochemical properties and pasting characteristics of flour and starch from red and white sweet potato cultivars. *Journal of Agricultural and Food Chemistry*, 51(8), 2232–2236.

Oti, E., and Akobundu, E. (2007). Physical, functional, and amylopectin content of starch from different cassava varieties. *Food Chemistry*, 101(2), 203–211.

Oti, E., Okonkwo, C., and Uchegbu, N. (2020). Effect of OFSP enrichment on vitamin A in snacks. *Journal of Agricultural Science and Food Technology*, 6(1), 5–11.

Owori, C., and Ssemakula, G. (2012). Acceptability of processed products from orange-fleshed sweet potato. *African Journal of Food, Agriculture, Nutrition and Development*, 12(5), 6445–6458.

Padayatty, S. J., Katz, A., Wang, Y., Eck, P., Kwon, O., Lee, J.-H., Chen, S., Corpe, C., Dutta, A., Dutta, S. K., & Levine, M. (2003). Vitamin C as an antioxidant: Evaluation of its role in disease prevention. *The American Journal of Clinical Nutrition*, 77(1), 3–16. https://doi.org/10.1093/ajcn/77.1.3

Rebellato, A. P., Silva, M. A., Behrens, J. H., & Almeida, M. A. (2015). Moisture recommendations for crackers: ≤ 14%, optimum ≈ 5%. *Heliyon,* 1(4), e00142. https://doi.org/10.1016/j.heliyon.2015.e00142

Rebellato, A.P., Beatriz, C. P., Juliana, P. P., and Juliana, A. L. P. (2015). Iron in fortified biscuits: A simple method for quantification, bioaccessibility study, and physicochemical quality. *Food Research International* 77 : 385–391

Singh, B., and Riar, C. S. (2014). Advances in cracker production technology. *Critical Reviews in Food Science and Nutrition,* 54(1), 37-51.

Tumwegamire, S., Kapinga, R., Zhang, D., Rismman, C. and Agili, S. (2007) Opportunities for promoting orange fleshed sweet potato as a mechanism for combating vitamin –A Deficiency in Sub-Saharan Africa. *African crop science Journal*. 12(3): 241-252

Uchendu F. N. and Oyediran E. O. (2022). Contribution of bread and biscuits to vitamin a daily requirement of preschool children in Lagos State, Nigeria, *European Journal of Clinical and Experimental Medicine*. 20, no. 1, 80–92.

Ujong, A. A. E., et al. (2023). Formulation of fiber-enriched crackers: Effects on nutritional and sensory properties. *Heliyon*, 9(1), e12800.

van Jaarsveld, P. J., Faber, M., Tanumihardjo, S. A., Nestel, P., Lombard, C. J., & Spinnler Benadé, A. J. (2006). β-Carotene–rich orange-fleshed sweet potato improves

Volume 2 (2025); Issue 3: 155-166
ISSN No:3078-5537

the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *The American Journal of Clinical Nutrition*, 83(5), 1080–1087.

Wafula, E. N., et al. (2021). Nutrient composition of OFSP value-added products. African *Journal of Food, Agriculture, Nutrition and Development*, 21(1), 17317–17337.

Wijesinha-Bettoni, R. (2019). The contribution of potatoes to global food security. *International Potato Center* (CIP). https://hdl.handle.net/10568/101555

Woolfe, J. (1992). Sweet potato: An untapped food resource. Cambridge University Press, Cambridge, UK

Zeist, A.R., Leal, M.H., Resende, J.T., Rech, C., Silva-Júnior, A.D., Toroco, B.R., Oliveira, J.N., and Oliveira, G.J. (2022). Selecting orange-fleshed sweet potato genotypes using selection indices. Horticulture Brasileira, 40(2), Article 231. https://doi.org/10.1590/S0102-0536-20220214.